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PROFILED RECESS FOR INSTRUMENTED EXPANDABLE COMPONENTS

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PROFILED RECESS FOR INSTRUMENTED EXPANDABLE COMPONENTS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to well completions using expandable components. More particularly, the present invention relates to a profiled recess incorporated into an expandable sand screen or other expandable downhole tubular. The profiled recess houses instrumentation lines or control lines in a wellbore.

Description of Related Art

[0002] Hydrocarbon wells are typically formed with a central wellbore that is supported by steel casing. The steel casing lines the borehole formed in the earth during the drilling process. This creates an annular area between the casing and the borehole, which is filled with cement to further support and form the wellbore.

[0003] Some wells are produced by perforating the casing of the wellbore at selected depths where hydrocarbons are found. Hydrocarbons migrate from the formation, through the perforations, and into the cased wellbore. In some instances, a lower portion of a wellbore is left open, that is, it is not lined with casing. This is known as an open hole completion. In that instance, hydrocarbons in an adjacent formation migrate directly into the wellbore where they are subsequently raised to the surface, typically through an artificial lift system.

[0004] Open hole completions carry the potential of higher production than a cased hole completion. They are frequently utilized in connection with horizontally drilled boreholes. However, open hole completions present various risks concerning the integrity of the open wellbore. In that respect, an open hole leaves aggregate material, including sand, free to invade the wellbore. Sand production can result in premature failure of artificial lift and other downhole and surface equipment. Sand can build up in the casing and tubing to obstruct well flow. Particles can compact and erode surrounding formations to cause liner and casing failures. In addition, produced sand

becomes difficult to handle and dispose at the surface. Ultimately, open holes carry the risk of complete collapse of the formation into the wellbore.

[0005] To control particle flow from unconsolidated formations, for example, well screens are often employed downhole along the uncased portion of the wellbore. One form of well screen recently developed is the expandable sand screen, known as Weatherford's ESS® tool. In general, the ESS® is constructed from three composite layers, including an intermediate filter media. The filter media allows hydrocarbons to invade the wellbore, but filters sand and other unwanted particles from entering. The sand screen is attached to production tubing at an upper end and the hydrocarbons travel to the surface of the well via the tubing. In one recent innovation, the sand screen is expanded downhole against the adjacent formation in order to preserve the integrity of the formation during production.

[0006] A more particular description of an expandable sand screen is described in U.S. Patent No. 5,901,789, which is incorporated by reference herein in its entirety. That patent describes an expandable sand screen which consists of a perforated base pipe, a woven filtering material, and a protective, perforated outer shroud. Both the base pipe and the outer shroud are expandable, and the woven filter is typically arranged over the base pipe in sheets that partially cover one another and slide across one another as the sand screen is expanded. The sand screen is expanded by a cone-shaped object urged along its inner bore or by an expander tool having radially outward extending rollers that are fluid powered from a tubular string. Using expander means like these, the sand screen is subjected to outwardly radial forces that urge the walls of the sand screen against the open formation. The sand screen components are stretched past their elastic limit, thereby increasing the inner and outer diameter of the sand screen.

[0007] The biggest advantage to the use of an expandable sand screen in an open wellbore like the one described herein is that once expanded, the annular area between the screen and the wellbore is mostly eliminated, and with it the need for a gravel pack. Typically, the ESS® is expanded to a point where its outer wall places a stress on the wall of the wellbore, thereby providing support to the walls of the wellbore to prevent

dislocation of particles.

[0008] In modern well completions, the operator oftentimes wishes to employ downhole tools or instruments. These include sliding sleeves, submersible electrical pumps, downhole chokes, and various sensing devices. These devices are controlled from the surface via hydraulic control lines, mechanical control lines, or even fiber optic cable. For example, the operator may wish to place a series of pressure and/or temperature sensors every ten meters within a portion of the hole, connected by a fiber optic line. This line would extend into that portion of the wellbore where an expandable tubular has been placed.

[0009] In order to protect the control lines or instrumentation lines, the lines are typically placed into small metal tubings which are affixed external to the completion tubular and the production tubing within the wellbore. In addition, in completions utilizing known non-expandable gravel packs, the control lines have been housed within a rectangular box. However, this method of housing control lines or instrumentation downhole is not feasible in the context of the new, expandable sand screens now being offered.

[0010] First, the presence of control lines behind an expandable completion tubular or tool interferes with an important function of the expandable tubular, which is to provide a close fit between the outside surface of the tubular and the formation wall (or surrounding casing). This is particularly true with the rectangular boxes normally used. The absence of a close fit between the outside surface of the expandable tubular and the formation wall creates a vertical channel outside of the sand screen, allowing formation fluids to migrate between formations therein, even to the surface. This, in turn, causes inaccurate pressure, temperature, or other readings from downhole instrumentation, particularly when the well is shut in for a period of time.

[0011] There is a need, therefore, for a protective encapsulation for control lines or instrumentation lines which does not hinder the expansion of the expandable tool closely against the formation wall (or casing). There is further a need for an encapsulation which does not leave a vertical channel outside of the expandable tubular when it is expanded against the formation wall (or casing). Still further, there is a need

for an encapsulation device which defines a recess in the wall of an expandable sand screen or other expandable downhole tool, and which provides enhanced protection to the control lines/fiber optics as it is expanded against the wall of a wellbore, whether cased or open.

SUMMARY OF THE INVENTION

[0012] The present invention provides a recess for housing instrumentation lines, control lines, or fiber optics downhole. In one aspect, the encapsulation defines a recess in the wall of an expandable tubular such as an expandable sand screen. Because the encapsulation resides within the wall of the downhole tool, no vertical channeling of fluids within the annulus outside of the tool, e.g., sand screen, occurs. The recess of the present invention may be employed whether the completion is cased or open.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

[0014] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0015] Figure 1 is a section view showing an open hole wellbore with an expandable sand screen disposed therein. A recess of the present invention is shown in cross-section within the wall of the expandable sand screen as an example of an expandable tubular. A traditional rectangular box is shown, in cross-section, running from the surface to the depth of the sand screen.

[0016] Figure 2 is a top section view of an expandable sand screen within an open wellbore. Visible is a profiled recess of the present invention residing in the outer layer of the sand screen wall. The sand screen is in its unexpanded state with an enlarged

view showing a portion of the sand screen expanded against the formation.

[0017] Figure 3 is also a top section view of an expandable sand screen within an open wellbore, with the recess in an alternate configuration. The sand screen is disposed within a cased wellbore in its unexpanded state.

[0018] Figure 4 is a top section view of an expandable sand screen before expansion, and a blow-up view of a portion of the expandable sand screen as expanded against a wellbore formation. An alternate embodiment of an encapsulation is demonstrated within the recess.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] **Figure 1** is a section view showing an open hole wellbore **40**. The wellbore **40** includes a central wellbore which is lined with casing **42**. The annular area between the casing **42** and the earth is filled with cement **46** as is typical in well completion. Extending downward from the central wellbore is an open hole wellbore **48**. A formation **50** is shown adjacent to the wellbore **48**.

[0020] Disposed in the open wellbore **48** is an expandable sand screen **20**. The expandable sand screen **20** is hung within the wellbore **40** from a hanging apparatus **32**. In some instances, the hanging apparatus **32** s a packer (not shown). In the depiction of **FIG. 1**, the hanging apparatus is a liner **30** and liner hanger **32**. A separate packer **34** is employed to seal the annulus between the liner **30** and the production tubular **44**.

[0021] Also depicted in **FIG. 1** is an upper hole encapsulation **12**. The upper hole encapsulation **12** shown is a cross-section of a standard rectangular-shaped box typically employed when running instrumentation lines or cable lines downhole. However, a specially profiled encapsulation may be used which contains arcuate walls, as disclosed in the pending application entitled "Profiled Encapsulation for Use With Expandable Sand Screen," having S/N No. .

[0022] The upper hole encapsulation **12** is shown running from the surface to the

depth of the sand screen **20**. The encapsulation **12** is secured to the production tubular **44** by clamps, shown schematically at **18**. Clamps **18** are typically secured to the production tubular **44** approximately every ten meters. The upper hole encapsulation **12** passes through the liner hanger **32** (or utilized hanging apparatus), and extends downward to a designated depth within the wellbore **40**. In the embodiment shown in **FIG. 1**, the encapsulation **12** extends to the top **21** of the sand screen **20**.

[0023] At or near the depth of the hanging apparatus **32**, the upper hole encapsulation **12** terminates. However, the instrumentation lines or cable lines **62** continue from the upper hole encapsulation **12** and to a desired depth. In **FIG. 1**, the lines **62** travel to the bottom **25** of the sand screen **20** and the open hole wellbore **48**.

[0024] In accordance with the present invention, the lines **62** reside within a novel recess **10** within the wall of an expandable tubular **20**. The exemplary expandable tubular **20** depicted in **FIG. 1** is an expandable sand screen. The recess **10** is visible in **FIG. 1** along the outside wall **26** of the sand screen **20**. The recess **10** serves as a housing for instrumentation lines or control lines **62**. For purposes of this application, such lines **62** include any type of data acquisition lines, communication lines, fiber optics, cables, sensors, and downhole "smart well" features.

[0025] **Figure 2** presents a top section view of a recess **10** of the present invention. In this view, the recess **10** is shown to reside within the outer layer **26** of an expandable tubular **20**. An enlarged section of the tubular **20** is shown expanded against the formation. Again, the depicted expandable tubular **20** is an expandable sand screen. However, it is within the scope of this invention to utilize a profiled recess **10** in any expandable tubular or tool.

[0026] In the embodiment of **FIG. 2**, the sand screen **20** is constructed from three composite layers. These define a slotted structural base pipe **22**, a layer of filter media **24**, and an outer protecting sheath, or "shroud" **26**. Both the base pipe **22** and the outer shroud **26** are configured to permit hydrocarbons to flow therethrough, such as through perforations (e.g., **23**) formed therein. The filter material **24** is held between the base

pipe **22** and the outer shroud **26,** and serves to filter sand and other particulates from entering the sand screen **20** and the production tubular **44**. Again, it is within the scope of this invention to utilize a profiled recess **10** in an expandable tool having any configuration of layers.

[0027] In the embodiment shown in **FIG. 2**, the recess **10** is specially profiled to conform to the arcuate profile of the expandable tubular **20**. To accomplish this, the recess **10** includes at least one arcuate wall **12**. In the embodiment of **FIG. 2**, the recess **10** defines an inner arcuate wall **12**, an outer arcuate wall **14**, and two end walls **16**. In this embodiment, the outer arcuate wall **14** includes an optional through-opening **14o** to aid in the insertion of lines **62**. In addition, the control or instrumentation lines **62** are housed within optional metal tubulars **60**. Finally, the embodiment in **FIG. 2** includes an optional filler material **64** in order to maintain the one or more lines **62** within the recess **10**. The filler material **64** may be an extrudable polymeric material such as polyethylene, a hardenable foam material such as polyethylene, or other suitable material for holding the lines **62** within the recess **10**.

[0028] Numerous alternate embodiments exist for the configuration of the recess **10** of the present invention. One exemplary alternate configuration for a recess **10** is shown in **Figure 3**. There, the recess **10** comprises a first inner arcuate wall **12** and a second outer arcuate wall **14**. The two arcuate walls **12** and **14** meet at opposite ends **16'**. However, it is within the scope of this invention to provide any shaped recess **10** formed essentially within any layer of the wall **26** of an expandable downhole tubular **20**. When the recess **10** of **FIGS. 2** or **3** or equivalent embodiments are employed, no vertical channel is left within the annular region **28** between the sand screen and the formation **50** after the sand screen **20** is expanded.

[0029] In another embodiment of the present invention, a separate profiled encapsulation **10'** is provided within the recess **10** of the expandable tubular **20**. Such an encapsulation **10'** is shown in **Figure 4** where the expandable tubular **20** is again, by way of example only, an expandable sand screen. **Figure 4** presents a portion **20e** of an expandable sand screen **20** in an expanded state. This demonstrates that the sand

screen **20** remains sand tight after expansion. (Note that the expanded depiction is not to scale.) Radial force applied to the inner wall of the perforated base pipe **22** forces the pipe **22** past its elastic limits and also expands the diameter of the base pipe perforations **23**. Also expanded is the shroud **26**. As shown in **Figure 4**, the shroud **26** is expanded to a point of contact with the formation **50**. Substantial contact between the sand screen **20** and the formation wall **48** places a slight stress on the formation **50**, reducing the risk of particulate matter entering the wellbore **48**. It also reduces the risk of vertical fluid flow behind the sand screen **20**.

[0030] The encapsulation **10'** is shown in **FIG. 4** to expand and deform with the recess **10**. The encapsulation **10'** is generally shaped to conform to the walls **12**, **14**, **16** of the recess **10**. In this manner, the encapsulation **10** defines at least a first arcuate wall **12'**. In the embodiment of **FIG. 4**, the encapsulation **10'** includes an inner arcuate wall **12'**, an outer arcuate wall **14'**, and two end walls **16'**. The encapsulation **10'** serves as the housing for the instrumentation lines or cable lines **62**. The encapsulation **10'** may be inserted into the recess **10** either as part of the manufacturing process, or at the well site during downhole tool run-in. The encapsulation **10'** is fabricated from a thermoplastic material which is durable enough to withstand abrasions while being pushed or press-fit into the recess **10**. At the same time, the encapsulation **10'** material must be sufficiently deformable to allow the encapsulation **10'** to generally comply with the expandable tubular **20** as it is expanded against the formation **50**.

[0031] Other embodiments for an encapsulation **10'** exist. For example, a crescent-shaped encapsulation (not shown), designed to reside within the profiled recess **10** of **Figure 3** could be employed. In each of the above embodiments, the recess **10** may optionally also house metal tubulars **60** for holding the control or instrumentation lines **62**. Metal tubulars **60** are demonstrated in the embodiments of **FIGS. 2** and **3**.

[0032] The sand screens **20** depicted in **FIGS. 1-4** are designed to expand. Expansion is typically done by a cone or compliant expander apparatus or other expander tool (not shown) to provide a close fit between the expandable tubular **20** and the formation **50**. In **Figure 1**, the sand screen **20** has already been expanded against

an open hole formation **50** so that no annular region remains. The sand screen **20** is thus in position for the production of hydrocarbons. The absence of an annular region substantially prohibits vertical movement of fluid behind the sand screen **20**.

[0033] On the other hand, the expandable tubular **20** in **FIG. 2** is in its unexpanded state. An annular region **28** is thus shown in **FIG. 2** between the sand screen **20** and the formation **50** within the wellbore **48**. In **Figure 3**, the sand screen **20** is again in an unexpanded state. However, in this embodiment recess **10** is disposed within an expandable tubular **20** within a cased wellbore. Casing **52** is shown circumferential to the sand screen **20**, creating an annulus **28**. Further, cement **54** is present around the casing **52**. Perforations **23'** are fired into the casing **52** in order to expose hydrocarbons or other formation fluids to the wellbore **48**. Thus, the recess **10** of the present invention has utility for both open hole and cased hole completions.

[0034] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.